Knowledge Clusters – Rivals in Innovation:
The Information Technology Industry

MERIC analyzed the U.S. Patent and Trademark Office data for all of the patents issued to originators within the 318 Metropolitan Statistical Areas (MSA) in the U.S. between 1995 and 1999 to determine (1) what groups of patent classes constitute a knowledge cluster, (2) which knowledge clusters Missouri's MSAs compete well in, and (3) which MSAs are in direct competition with St. Louis and Kansas City in the generation of new knowledge.

Key Findings:

Seven knowledge clusters were identified in information technology. These include:

1. *Electromagnetic Wave and Laser Communications*
2. *High Energy Light Physics*
3. *Cryptography, Artificial Intelligence and Computer Speech*
4. *Television and Digital Image Processing*
5. *Semiconductor Manufacturing*
6. *Measurement and Calibration Instrument Manufacture and*
7. *Electrical Computer Manufacturing and Process Coordination.*

Missouri generates more patents in *Electromagnetic Wave and Laser Communications; Cryptography, Artificial Intelligence and Computer Speech; Television and Digital Image Processing and High Energy Light Physics* than in the other information technology knowledge clusters. However, the number of patents per 100,000 population generated by Missouri's MSAs and their national rankings indicate that St. Louis, Kansas City and Columbia are not major originators of information technology related patents.

Missouri does rank high in the concentration of employment in the communications industry. This suggests that increasing certain types of innovation and exploiting the current level of innovation through the development of marketable goods and services can enhance the state's level of prosperity.

Knowledge Clusters – Rivals in Innovation: The Information Technology Industry

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Analysis and Reporting by Timothy O. Smith, Ph.D.

Overview:

MERIC analyzed the U.S. Patent and Trademark Office data for all of the patents issued to originators within the 318 Metropolitan Statistical Areas (MSA) in the U.S. between 1995 and 1999. This was done to determine (1) what patent classes group together to constitute a knowledge cluster, (2) which knowledge clusters Missouri's MSAs compete well in, and (3) which MSAs in other states are in direct competition with Missouri's MSAs in the generation of new knowledge. Seven knowledge clusters were identified in information technology. The names of these clusters are derived from the patent classes that grouped together. The seven knowledge clusters in information technology production include:

1. *Electromagnetic Wave and Laser Communications*
2. *High Energy Light Physics*
3. *Cryptography, Artificial Intelligence and Computer Speech*
4. *Television and Digital Image Processing*
5. *Semiconductor Manufacturing and*
6. *Measurement and Calibration Instrument Manufacture*
7. *Electrical Computer Manufacturing and Process Coordination.*

MERIC calculated the number of patents per 100,000 population in each of these patent clusters for all 318 MSAs. Missouri produced more patents in *Electromagnetic Wave and Laser Communications; Cryptography, Artificial Intelligence and Computer Speech; Television and Digital Image Processing and High Energy Light Physics* than in the other information technology knowledge clusters. A detailed list of the patent classes which constitute each cluster is presented in the Appendix.

Objectives:

The first objective of this study is to identify knowledge clusters using only public data sources, and allow that data to dictate which patent classes should be linked together. This technique is limited by the types of patents actually being applied for during the five years studied, but it makes up for this limitation by linking types of knowledge actually being developed in the same place at the same time.

The second objective is to determine how Missouri's efforts in innovation correspond with Missouri's "cash crop" industries. Are Missouri's knowledge cluster patents being explored and exploited to help its businesses sell more goods and services to other states than it buys from them? In which industries and knowledge clusters could Missouri begin to do this more effectively?

Method:

A database was constructed using data from the U.S. Patent and Trademark Office web site to reflect the number of patents issued between 1995 and 1999 for each of the 318 MSAs by patent class. Cluster analysis and factor analysis were used in combination to group the patent classes. Patent classes were organized so that patent types being generated in the same geographic area would group together as knowledge clusters. In this way a publicly available database is used to determine the structure and components of knowledge clusters. The only assumption in this analysis is that innovation in different patent classes is based upon an understanding of more basic theoretical principles. The understanding of theoretical principles is geographically bound therefore those patent classes with highly correlated locations of origin must share a common knowledge structure. Discovery of both the underlying knowledge structure and the geographic location where those structures are located result from the data analysis undertaken.

Missouri's Niche in Information Technology:

Table 1 shows the degree of Missouri's current efforts in innovation in information technology. Between 1995 and 1999, 7.7% of the patents generated in St. Louis, 8.5% of the patents generated in Kansas City, and 12.6% of the patents generated in Columbia were in information technology related patent classes.

Table 1: Patent Clusters with the Most Patents Issued 1995 to 1999

St. Louis MO-IL MSA	**Percent**
Packaging, Dispensing and Exhibiting Products	13.70%
Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	10.61%
Organic Pharmaceutical Chemistry and Manufacturing	10.05%
Electrical Heating Devices Manufacture	5.24%
Surgical Processes, Techniques and Apparatus	5.24%
Fluid Materials Handling and Refrigeration	4.96%
Electromagnetic Wave and Laser Communications	4.18%
Measurement and Calibration Instrument Manufacturing	3.49%
Materials Coating Processes	1.81%
Motor Vehicle Manufacturing	1.81%
Percent of St. Louis Patents between 1995 and 1999	**61.09%**

Kansas City MO-KS MSA	**Percent**
Surgical Processes, Techniques and Apparatus	9.14%
Packaging, Dispensing and Exhibiting Products	6.22%
Electrical Heating Devices Manufacture	5.56%
Fluid Materials Handling and Refrigeration	5.37%
Organic Pharmaceutical Chemistry and Manufacturing	5.00%
Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	4.81%
Electromagnetic Wave and Laser Communications	4.52%
Motor Vehicle Manufacturing	4.43%
Cryptography, Artificial Intelligence and Computer Speech	3.96%
Printing	3.11%
Percent of Kansas City Patents between 1995 and 1999	**52.12%**

Columbia MO MSA	Percent
Organic Pharmaceutical Chemistry and Manufacturing	19.33%
Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	10.08%
Fluid Materials Handling and Refrigeration	10.08%
Surgical Techniques and Apparatus	8.40%
Packaging, Dispensing and Exhibiting Products	6.72%
Measurement and Calibration Instrument Manufacturing	5.04%
Motor Vehicle Manufacturing	4.20%
Cryptography, Artificial Intelligence and Computer Speech	3.36%
Television and Digital Image Processing	2.52%
Electrical Computer Manufacturing and Process Coordination	1.68%
Percent of Columbia Patents between 1995 and 1999	**71.34%**

Paraphrasing Dr. Michael Porter's work on using knowledge clusters to enhance regional prosperity: *You must use what you have, in terms of the existing industrial base and innovative capacity, to build what you need. Without ignoring any business sector, concentrate on those sectors that are exporting more goods and services to the rest of the nation than they are importing into the state.* The location quotient is one measure of this distinction between industrial sectors.

Missouri's Export Industries (To Other States):

A location quotient greater than one (1.0) indicates that the level of employment in that industry exceeds the level necessary to satisfy the local demand for the goods or services which it produces. The location quotient thus measures the portion of an industry's workforce in excess of that used to supply the needs of the local market. The long-term projections model, used by the U.S. Department of Labor, Bureau of Labor Statistics, uses a threshold value of 1.2 to distinguish those industries which primarily supply local demand from those that export goods and services to the rest of the nation. This takes into account the circumstance where some local industries may have larger employment concentrations compared to the nation, but are still primarily local serving. Comparison of the location quotients for a given industry across all of the states will provide a representation of the market share of that industry captured and supplied by each state with a location quotient greater than 1.2.

Table 2 presents by two-digit SIC code those Missouri industries with the highest location quotients. Using "Communications" to illustrate how to read this table, the location quotient of 1.5 indicates that .3 (1.5-1.2) of the indicator is engaged in export outside the state. This means that 20% (.3/1.5) of communications industry workers in Missouri are engaged in supplying export goods and services to other states. The "Communications" industry corresponds most closely to Missouri's most innovative information technology clusters. The location quotient of 1.50 for this industry indicates that although Missouri is not very innovative in the information technology clusters, the innovations that are being produced are also being converted into products that allow Missouri to capture a portion of the information technology market.

Table 2: Missouri's Top 20 Export Industries (To Other States)

SIC Code	SIC Title	Location Quotient	Percent of Wages Paid
3100	Leather and Leather Products	2.30	0.115%
1400	Nonmetallic Minerals, except Fuels	1.55	0.163%
4800	Communications	1.50	2.614%
2000	Food and Kindred Products	1.48	2.613%
3700	Transportation Equipment	1.48	3.401%
4000	Railroad Transportation	1.44	0.001%
4200	Trucking and Warehousing	1.41	2.005%
6200	Security and Commodity Brokers	1.30	1.674%
2700	Printing and Publishing	1.29	1.700%
5500	Automotive Dealers & Service Stations	1.27	2.010%
2500	Furniture and Fixtures	1.26	0.555%
5300	General Merchandise Stores	1.24	1.499%
4300	U.S. Postal Service	1.23	1.012%
8000	Health Services	1.23	9.280%
1000	Metal Mining	1.19	0.045%
2800	Chemicals and Allied Products	1.18	1.627%
7900	Amusement & Recreation Services	1.15	1.211%
8600	Membership Organizations	1.15	0.487%
4900	Electric, Gas and Sanitary Services	1.13	1.441%
3400	Fabricated Metal Products	1.12	1.416%

The Location Quotient is based on 2000 employment data. The Percent of Wages Paid is based on 2001 covered employment and wage data.

The Competition in Information Technology:

There are 318 Metropolitan Statistical Areas (MSA) in the U.S. The rankings of the 6 Missouri MSAs and the clusters in which they are most involved are presented in Tables 3 through 9 (all rankings are of patents per 100,000 population.). The number of patents per 100,000 population generated by Missouri's MSAs and their national rankings indicate that St. Louis, Kansas City and Columbia are not currently major originators of information technology related patents. In a previous report, MERIC investigated which MSAs had grown fastest in their overall generation of patents (see *Innovation Clusters in the Decade of the 1990s*, January 2002). Fourteen of the eighteen fastest growing MSAs in terms of overall patent development between 1990 and 1999 ranked high in the generation of information technology patents (San Jose CA, Boise City ID, Rochester MN, Burlington VT, Boulder-Longmont CO, Austin-San Marcos TX, Dutchess County NY, Santa Cruz-Watsonville CA, Corvallis OR, San Francisco CA, Fort Collins-Loveland CO, Raleigh-Durham-Chapel Hill NC, Rochester NY and Binghampton NY).

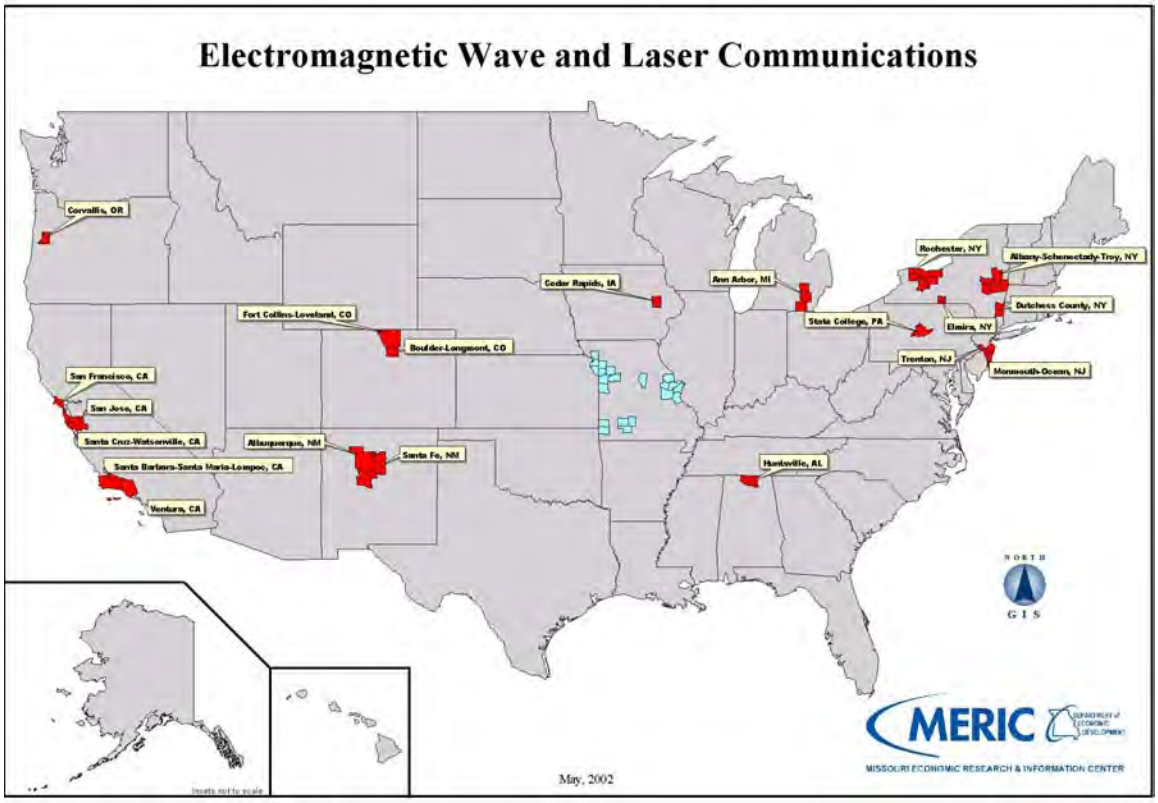

Table 3: Patent Rankings in Electromagnetic Wave and Laser Communications

Electromagnetic Wave and Laser Communications	**Patents per 100,000**	**# of 318**
San Jose CA PMSA	70.68	1st
Boulder-Longmont CO PMSA	52.26	2nd
Santa Fe NM MSA	35.21	3rd
Rochester NY MSA	33.53	4th
Santa Barbara-Santa Maria-Lompoc CA MSA	32.63	5th
Monmouth-Ocean NJ PMSA	26.40	6th
Santa Cruz-Watsonville CA PMSA	26.30	7th
Albuquerque NM MSA	26.08	8th
Trenton NJ PMSA	22.66	9th
Ann Arbor MI PMSA	22.26	10th
Missouri's MSAs		
St. Louis MO-IL MSA	5.24	77th
Kansas City MO-KS MSA	2.80	124th
Columbia MO MSA	1.57	164th
Springfield MO MSA	1.33	174th
Joplin MO MSA	0.00	288th
St. Joseph MO MSA	0.00	306th

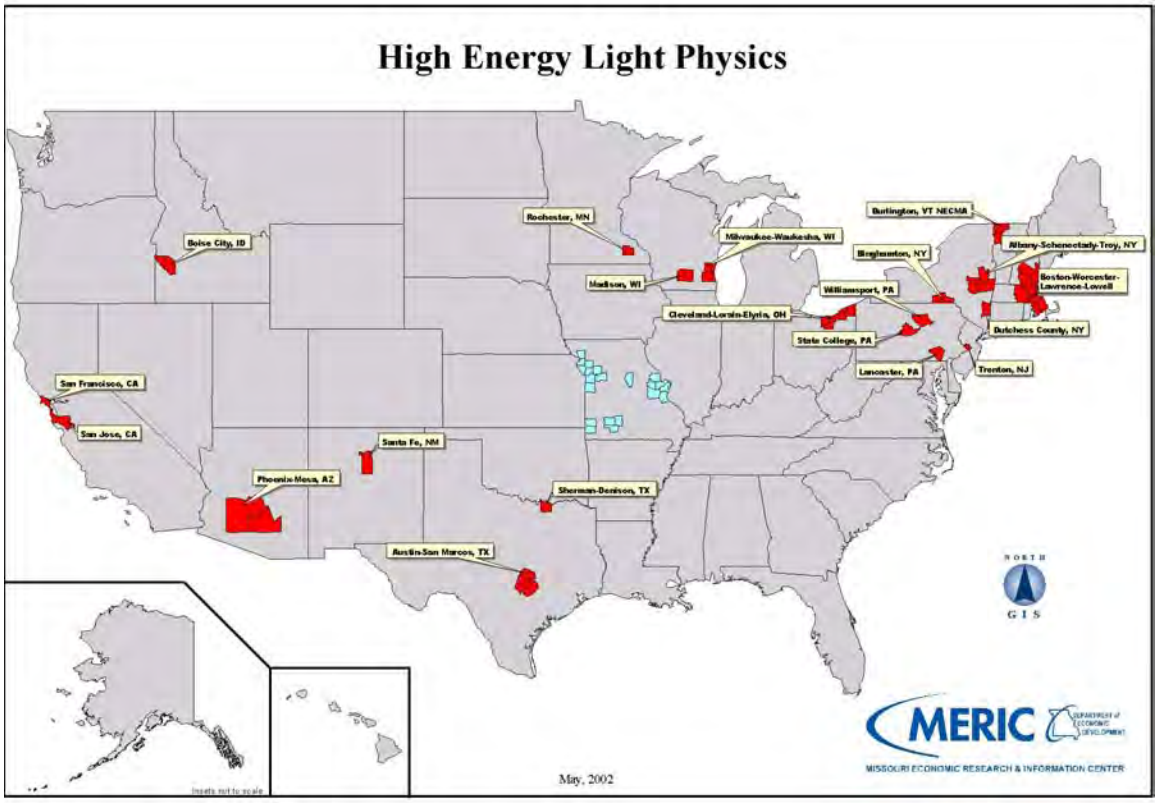

Table 4: Patent Rankings in High Energy Light Physics

High Energy Light Physics	**Patents Per 100,000**	**# of 318**
Boise City ID MSA	15.62	1st
Burlington VT NECMA	13.49	2nd
Rochester MN MSA	13.02	3rd
Sherman-Denison TX MSA	12.89	4th
Albany-Schenectady-Troy NY MSA	11.21	5th
Dutchess County NY PMSA	10.22	6th
Trenton NJ PMSA	9.97	7th
San Jose CA PMSA	8.36	8th
Madison WI MSA	6.67	9th
Milwaukee-Waukesha WI PMSA	6.37	10th
Missouri's MSAs		
St. Louis MO-IL MSA	1.21	57th
Kansas City MO-KS MSA	0.12	141st
Columbia MO MSA	0.00	174th
Joplin MO MSA	0.00	229th
Springfield MO MSA	0.00	294th
St. Joseph MO MSA	0.00	296th

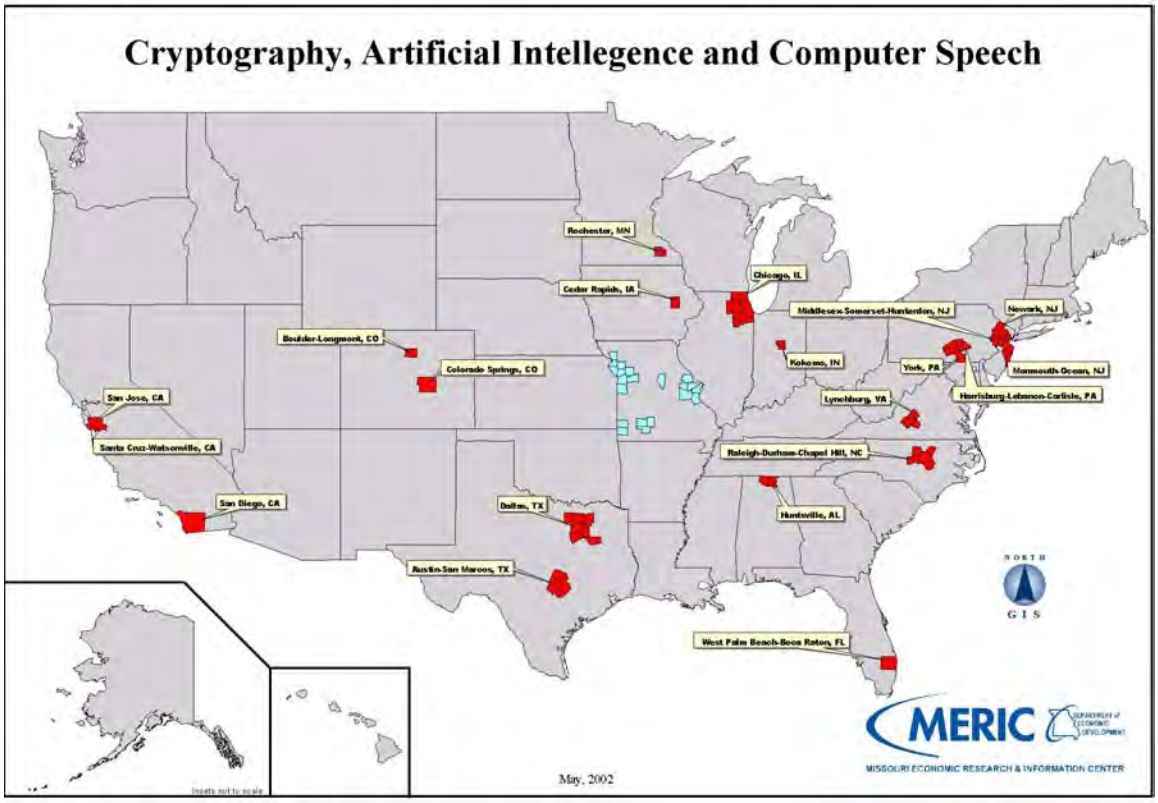

Table 5: Patent Rankings in Cryptography, Artificial Intelligence and Computer Speech

Cryptography, Artificial Intelligence and Computer Speech	**Patents Per 100,000**	**# of 318**
San Jose CA PMSA	77.06	1st
Boulder-Longmont CO PMSA	71.33	2nd
Cedar Rapids IA MSA	54.51	3rd
Harrisburg-Lebanon-Carlisle PA MSA	47.65	4th
Monmouth-Ocean NJ PMSA	46.69	5th
Raleigh-Durham-Chapel Hill NC MSA	36.76	6th
Lynchburg VA MSA	35.35	7th
Middlesex-Somerset-Hunterdon NJ PMSA	32.34	8th
Austin-San Marcos TX MSA	25.49	9th
Rochester MN MSA	24.30	10th
Missouri's MSAs		
Columbia MO MSA	3.14	91st
Kansas City MO-KS MSA	2.45	109th
St. Louis MO-IL MSA	1.68	133rd
Springfield MO MSA	0.66	196th
Joplin MO MSA	0.00	278th
St. Joseph MO MSA	0.00	304th

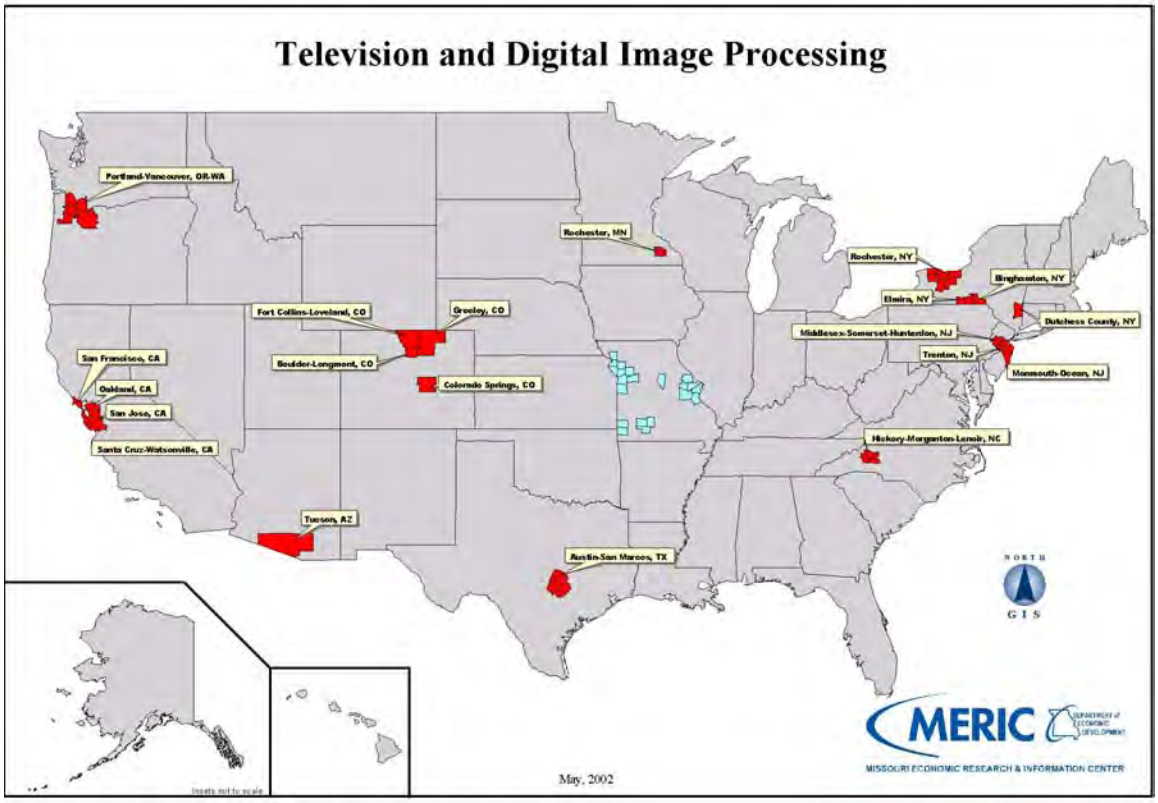

Table 6: Patent Rankings in Television and Digital Image Processing

Television and Digital Image Processing	**Patents Per 100,000**	**# of 318**
San Jose CA PMSA	60.65	1st
Rochester NY MSA	39.35	2nd
Trenton NJ PMSA	39.29	3rd
Elmira NY MSA	34.50	4th
Boulder-Longmont CO PMSA	31.66	5th
Fort Collins-Loveland CO MSA	25.62	6th
Middlesex-Somerset-Hunterdon NJ PMSA	19.93	7th
Hickory-Morganton-Lenoir NC MSA	19.81	8th
Monmouth-Ocean NJ PMSA	17.79	9th
San Francisco CA PMSA	16.62	10th
Missouri's MSAs		
Columbia MO MSA	2.36	92nd
St. Louis MO-IL MSA	1.88	113th
Kansas City MO-KS MSA	0.93	152nd
Joplin MO MSA	0.68	189th
Springfield MO MSA	0.00	304th
St. Joseph MO MSA	0.00	306th

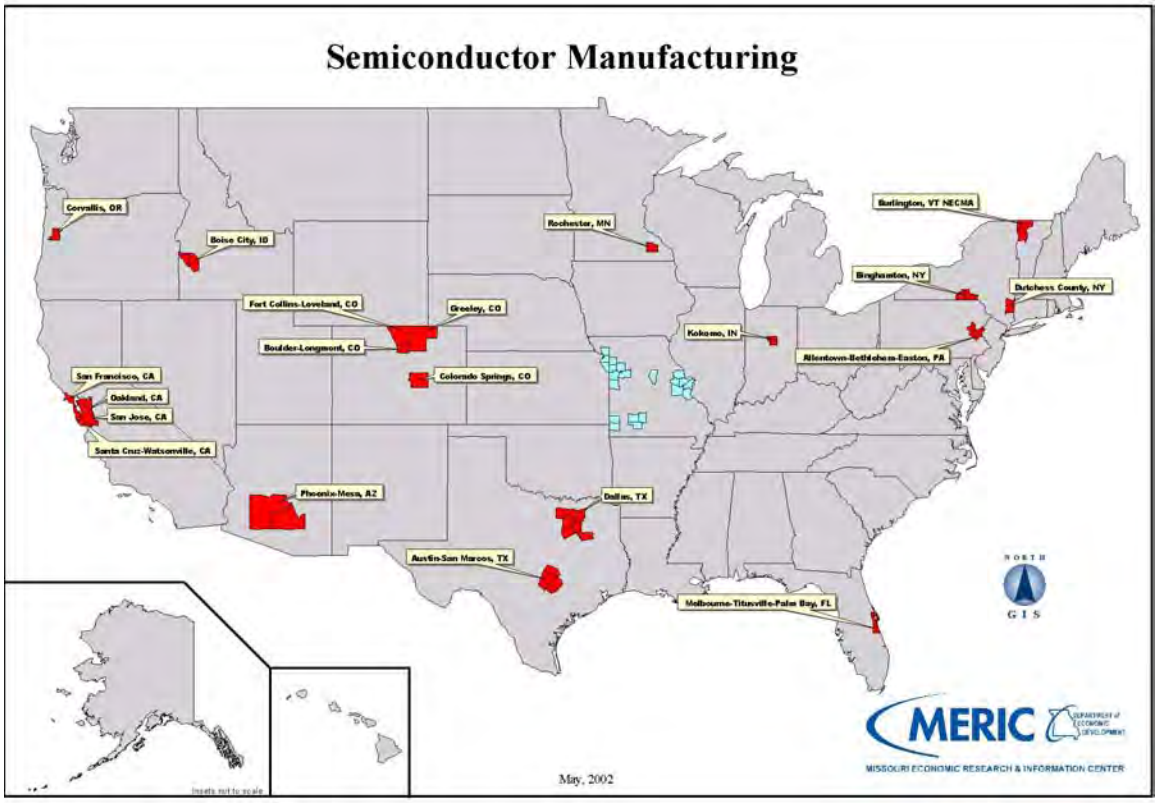

Table 7: Patent Rankings in Semiconductor Manufacturing

Semiconductor Manufacturing	**Patents per 100,000**	**# of 318**
Boise City ID MSA	382.13	1st
San Jose CA PMSA	311.91	2nd
Burlington VT NECMA	291.29	3rd
Rochester MN MSA	171.86	4th
Dutchess County NY PMSA	153.63	5th
Austin-San Marcos TX MSA	114.73	6th
Boulder-Longmont CO PMSA	90.02	7th
Santa Cruz-Watsonville CA PMSA	87.26	8th
Fort Collins-Loveland CO MSA	67.59	9th
Corvallis OR MSA	58.40	10th
Missouri's MSAs		
St. Louis MO-IL MSA	1.29	117th
Columbia MO MSA	0.79	140th
Springfield MO MSA	0.66	152nd
Kansas City MO-KS MSA	0.35	185th
Joplin MO MSA	0.00	266th
St. Joseph MO MSA	0.00	306th

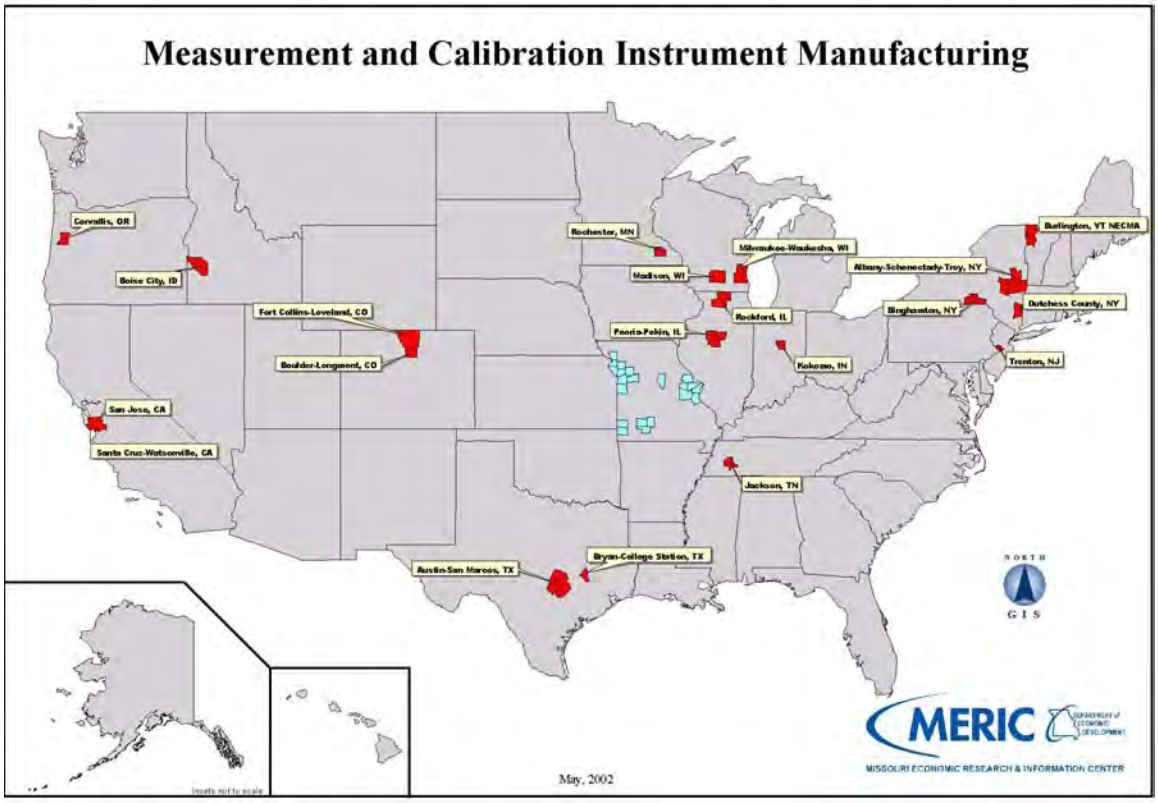

Table 8: Patent Rankings in Measurement and Calibration Instrument Manufacturing

Measurement and Calibration Instrument Manufacturing	**Patents per 100,000**	**# of 318**
Boise City ID MSA	51.54	1st
San Jose CA PMSA	51.04	2nd
Dutchess County NY PMSA	44.27	3rd
Burlington VT NECMA	41.70	4th
Binghamton NY MSA	26.24	5th
Rochester MN MSA	22.57	6th
Austin-San Marcos TX MSA	21.75	7th
Albany-Schenectady-Troy NY MSA	20.25	8th
Fort Collins-Loveland CO MSA	19.88	9th
Santa Cruz-Watsonville CA PMSA	19.20	10th
Missouri's MSAs		
Columbia MO MSA	4.72	116th
St. Louis MO-IL MSA	4.38	127th
Joplin MO MSA	4.08	135th
St. Joseph MO MSA	2.06	198th
Kansas City MO-KS MSA	1.86	209th
Springfield MO MSA	0.00	312th

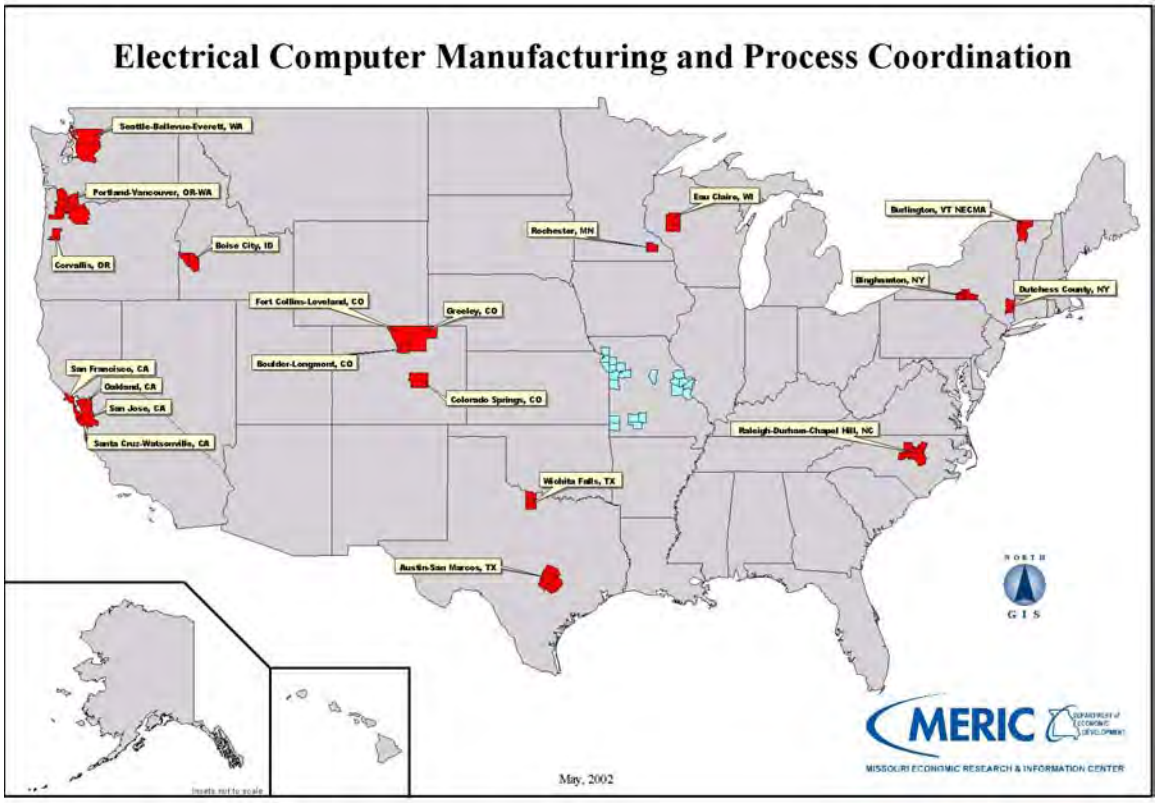

Table 9: Patent Rankings in Electrical Computer Manufacturing and Process Coordination

Electrical Computer Manufacturing and Process Coordination	Patents per 100,000	# of 318
San Jose CA PMSA	276.04	1st
Rochester MN MSA	241.29	2nd
Austin-San Marcos TX MSA	214.25	3rd
Fort Collins-Loveland CO MSA	128.12	4th
Dutchess County NY PMSA	127.15	5th
Burlington VT NECMA	97.50	6th
Santa Cruz-Watsonville CA PMSA	86.84	7th
Binghamton NY MSA	78.73	8th
Boulder-Longmont CO PMSA	78.57	9th
Boise City ID MSA	64.82	10th
Missouri's MSAs		
Kansas City MO-KS MSA	1.81	124th
Columbia MO MSA	1.57	134th
St. Louis MO-IL MSA	1.25	152nd
Springfield MO MSA	1.00	174th
Joplin MO MSA	0.00	270th
St. Joseph MO MSA	0.00	300th

Conclusion:

Missouri does not generate a large proportion of its patents in information technology related patent classes. However, the concentration of employment in the communications industry indicates that application of those patents being produced can have a major effect on the production of goods and services in Missouri. Some of the fastest growing and most innovative cities in the nation have increased their level of innovation in the IT knowledge clusters during the decade of the 1990s. Information technology appears to be an area where Missouri is not very innovative, but where increasing certain types of innovation and exploiting the current level of innovation through the development of marketable goods and services can enhance the state's level of prosperity.

Appendix:

The locations of origin for the following information technology patent classes were sufficiently linked to consider these class groupings as a distinct knowledge cluster.

Electrical Computer Manufacturing and Process Coordination
Class 341 , Coded Data Generation or Conversion
Class 361 , Electricity: Electrical Systems and Devices
Class 708 , Electrical Computers: Arithmetic Processing and Calculating
Class 710 , Electrical Computers and Digital Data Processing Systems: Input/Output
Class 711 , Electrical Computers and Digital Processing Systems: Memory
Class 712 , Electrical Computers and Digital Processing Systems: Processing Architectures and Instruction Processing (e.g., Processors)
Class 713 , Electrical Computers and Digital Processing Systems: Support
Class 714 , Error Detection/Correction and Fault Detection/Recovery
Class 345 , Computer Graphics Processing, Operator Interface Processing, and Selective Visual Display Systems
Class 709 , Electrical Computers and Digital Processing Systems: Multiple Computer or Process Coordinating
Class 707 , Data Processing: Database and File Management, Data Structures, or Document Processing
Class 377 , Electrical Pulse Counters, Pulse Dividers, or Shift Registers: Circuits and Systems

Television and Digital Image Processing
Class 382 , Image Analysis
Class 700 , Data Processing: Generic Control Systems or Specific Applications
Class 348 , Television
Class 178 , Telegraphy
Class 369 , Dynamic Information Storage or Retrieval
Class 204 , Chemistry: Electrical and Wave Energy
Class 385 , Optical Waveguides

High Energy Light Physics *
Class 117 , Single-Crystal, Oriented-Crystal, and Epitaxy Growth Processes; Non-Coating Apparatus Therefor
Class 378 , X-Ray or Gamma Ray Systems or Devices
Class 706 , Data Processing: Artificial Intelligence
Class 313 , Electric Lamp and Discharge Devices
Class 445 , Electric Lamp or Space Discharge Component or Device Manufacturing

Cryptography, Artificial Intelligence and Computer Speech *
Class 370 , Multiplex Communications
Class 380 , Cryptography
Class 704 , Data Processing: Speech Signal Processing, Linguistics, Language Translation, and Audio Compression/Decompression
Class 505 , Superconductor Technology: Apparatus, Material, Process
Class 375 , Pulse or Digital Communications
Class 379 , Telephonic Communications
Class 455 , Telecommunications
Class 329 , Demodulators
Class 315 , Electric Lamp and Discharge Devices: Systems
Class 439 , Electrical Connectors
Class 332 , Modulators

* Artificial Intelligence (Class 706) and Computer Speech (Class 704) both load heavily in the factor analysis of the "High Energy Light Physics" and "Cryptography, Artificial Intelligence and Computer Speech" clusters. All of the other elements that contributed to these factor definitions showed marked distinctiveness in the factor loading.

Semiconductor Manufacturing
Class 365 , Static Information Storage and Retrieval
Class 326 , Electronic Digital Logic Circuitry
Class 257 , Active Solid-State Devices (e.g., Transistors, Solid-State Diodes)
Class 438 , Semiconductor Device Manufacturing: Process
Class 395 , Information Processing System Organization
Class 216 , Etching a Substrate: Processes
Class 323 , Electricity: Power Supply or Regulation Systems
Class 331 , Oscillators
Class 360 , Dynamic Magnetic Information Storage or Retrieval
Class 330 , Amplifiers
Class 118 , Coating Apparatus
Class 327 , Miscellaneous Active Electrical Nonlinear Devices, Circuits, and Systems

Measurement and Calibration Instrument Manufacture
Class 324 , Electricity: Measuring and Testing
Class 702 , Data Processing: Measuring, Calibrating, or Testing
Class 033 , Geometrical Instruments
Class 374 , Thermal Measuring and Testing
Class 414 , Material or Article Handling
Class 434 , Education and Demonstration
Class 134 , Cleaning and Liquid Contact with Solids
Class 451 , Abrading
Class 174 , Electricity: Conductors and Insulators
Class 392 , Electric Resistance Heating Devices
Class 205 , Electrolysis: Processes, Compositions Used Therein, and Methods of Preparing the Compositions
Class 429 , Chemistry: Electrical Current Producing Apparatus, Product, and Process
Class 363 , Electric Power Conversion Systems
Class 338 , Electrical Resistors
Class 494 , Imperforate Bowl: Centrifugal Separators

Electromagnetic Wave and Laser Communications
Class 250 , Radiant Energy
Class 359 , Optics: Systems (Including Communication) and Elements
Class 356 , Optics: Measuring and Testing
Class 381 , Electrical Audio Signal Processing Systems and Devices
Class 342 , Communications: Directive Radio Wave Systems and Devices (e.g., Radar, Radio Navigation)
Class 333 , Wave Transmission Lines and Networks
Class 372 , Coherent Light Generators
Class 343 , Communications: Radio Wave Antennas
Class 386 , Television Signal Processing for Dynamic Recording or Reproducing
Class 136 , Batteries: Thermoelectric and Photoelectric
Class 336 , Inductor Devices
Class 310 , Electrical Generator or Motor Structure
Class 320 , Electricity: Battery or Capacitor Charging or Discharging